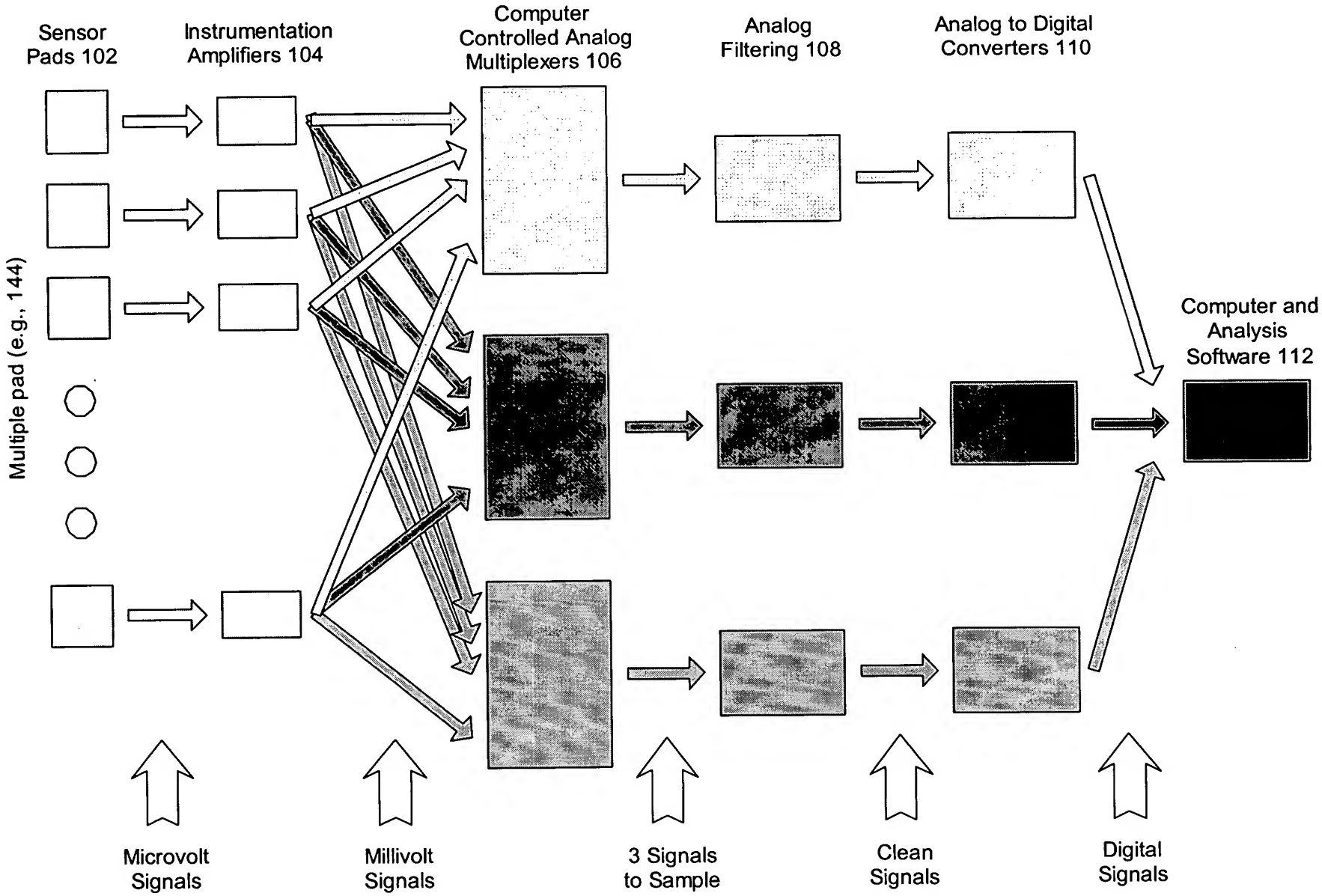

Sensor Pads 102
Instrumentation Amplifiers 104
Computer Controlled Analog Multiplexers 106
Analog Filtering 108
Analog to Digital Converters 110
Computer and Analysis Software 112
Multiple pad (e.g., 144)
Microvolt Signals
Millivolt Signals
3 Signals to Sample
Clean Signals
Digital Signals

FIG. 1

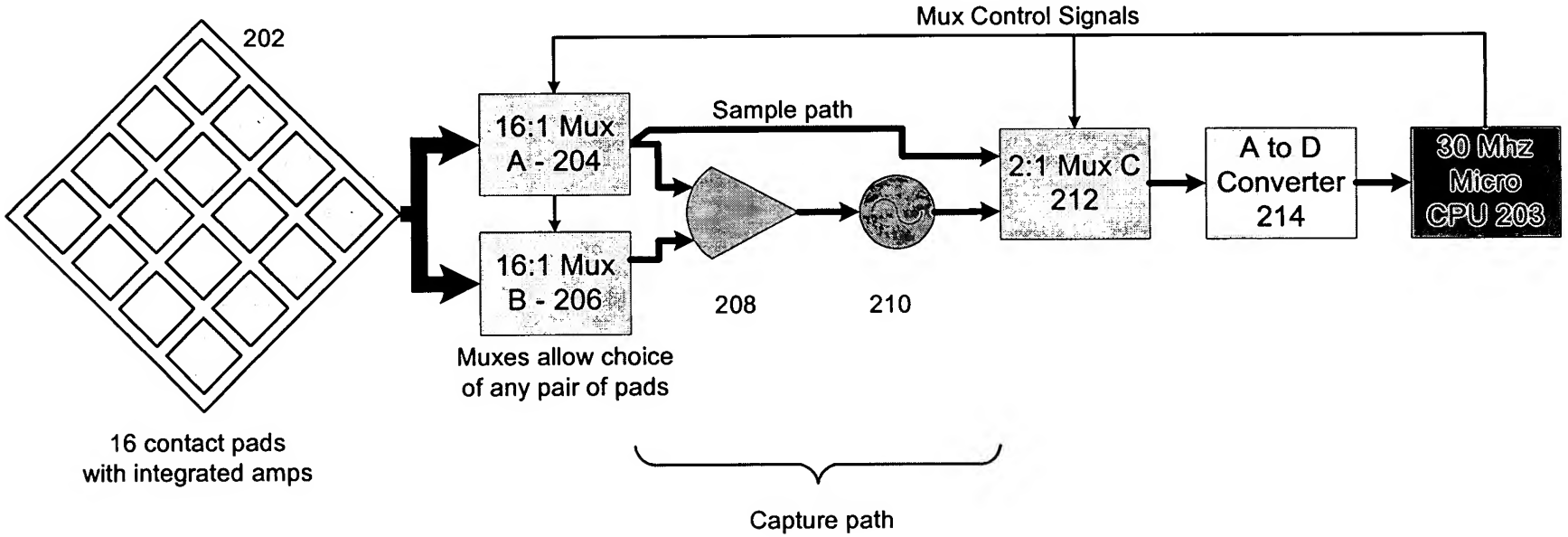

Mux Control Signals
202
16:1 Mux
A - 204
Sample path
2:1 Mux C
212
A to D
Converter
214
30 Mhz
Micro
CPU 203
16:1 Mux
B - 206
208
210
Muxes allow choice
of any pair of pads
16 contact pads
with integrated amps
Capture path

FIG. 2

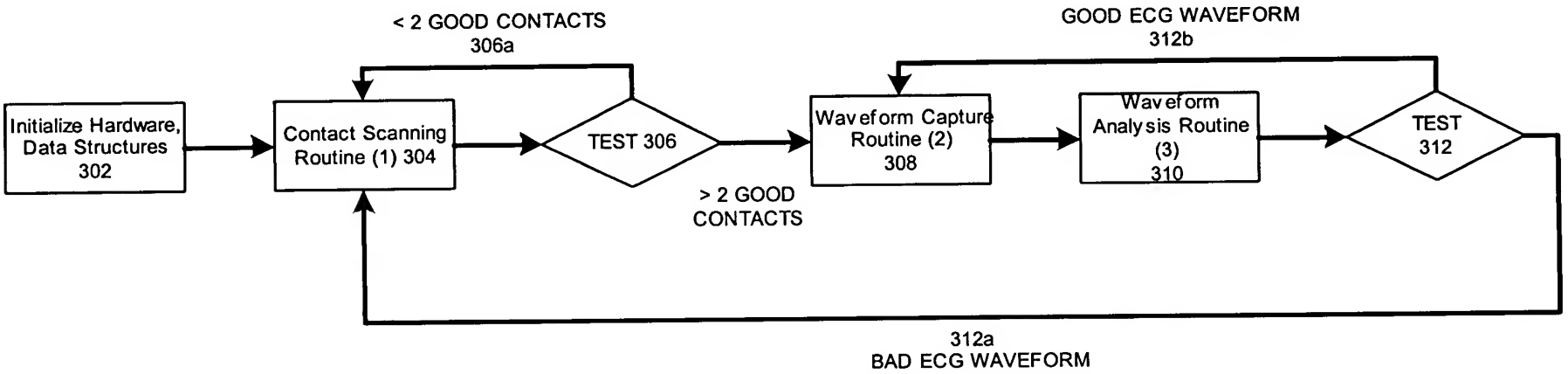

< 2 GOOD CONTACTS
306a
GOOD ECG WAVEFORM
312b
Initialize Hardware, Data Structures 302
Contact Scanning Routine (1) 304
TEST 306
> 2 GOOD CONTACTS
Waveform Capture Routine (2) 308
Waveform Analysis Routine (3) 310
TEST 312
312a
BAD ECG WAVEFORM

FIG. 3

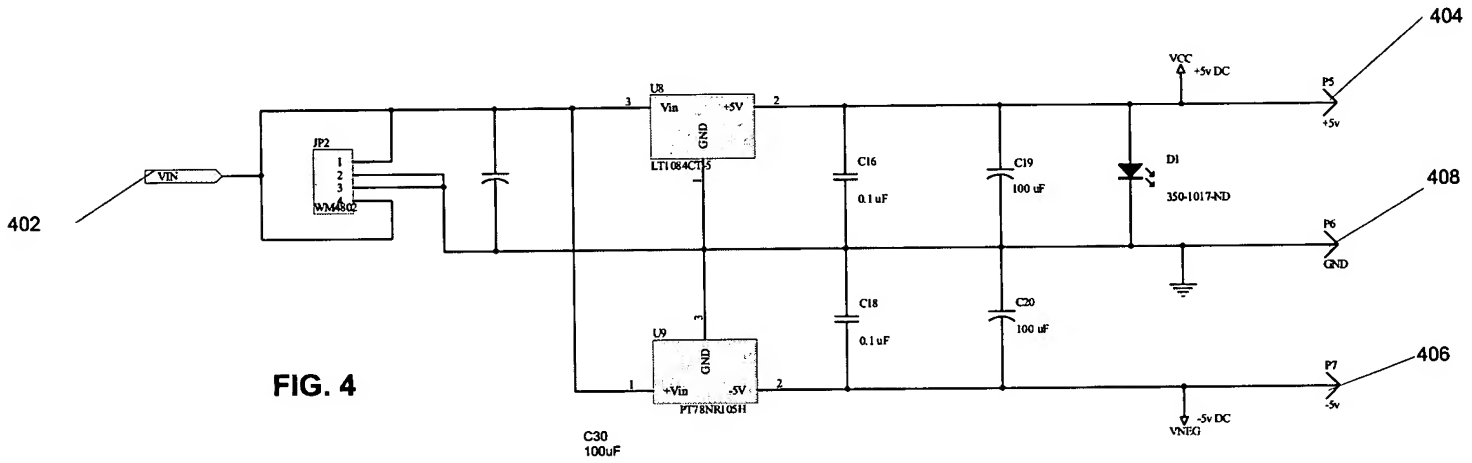

402
404
408
406
VIN
JP2
WM4802
U8
Vin
+5V
GND
LT1084CT-5
C16
0.1 uF
C19
100 uF
D1
350-1017-ND
VCC
+5v DC
P5
+5v
P6
GND
C18
0.1 uF
C20
100 uF
U9
GND
+Vin
-5V
PT78NR105H
P7
-5v
-5v DC
VNEG
C30
100uF

FIG. 4

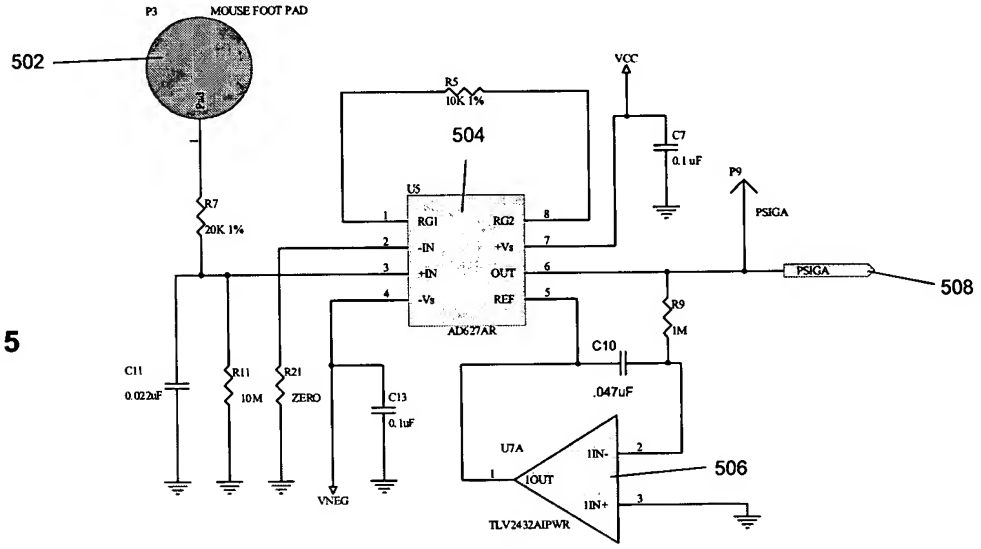

502
P3
MOUSE FOOT PAD
504
R5
10K 1%
VCC
C7
0.1 uF
P9
PSIGA
U5
RG1
-IN
+IN
-Vs
RG2
+Vs
OUT
REF
AD627AR
R7
20K 1%
PSIGA
508
R9
1M
C10
.047uF
C11
0.022uF
R11
10M
R21
ZERO
C13
0.1uF
VNEG
U7A
1IN-
1OUT
1IN+
TLV2432AIPWR
506

FIG. 5

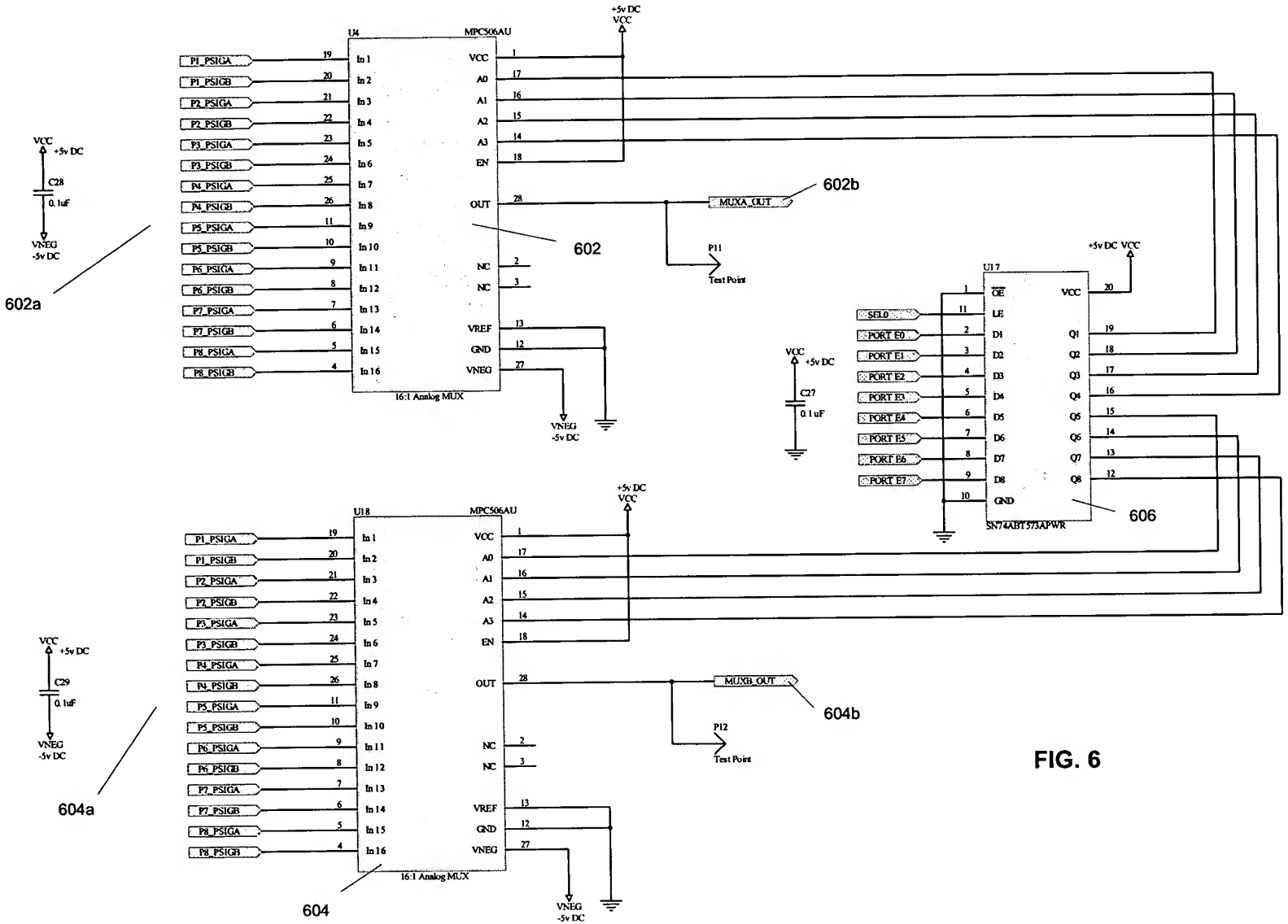

U4
MPC506AU
P1_PSIGA
P1_PSIGB
P2_PSIGA
P2_PSIGB
P3_PSIGA
P3_PSIGB
P4_PSIGA
P4_PSIGB
P5_PSIGA
P5_PSIGB
P6_PSIGA
P6_PSIGB
P7_PSIGA
P7_PSIGB
P8_PSIGA
P8_PSIGB
In 1
In 2
In 3
In 4
In 5
In 6
In 7
In 8
In 9
In 10
In 11
In 12
In 13
In 14
In 15
In 16
VCC
A0
A1
A2
A3
EN
OUT
NC
NC
VREF
GND
VNEG
16:1 Analog MUX
+5v DC
VCC
MUXA_OUT
602b
602
P11
Test Point
602a
VCC
+5v DC
C28
0.1uF
VNEG
-5v DC
U17
SN74ABT573APWR
OE
LE
D1
D2
D3
D4
D5
D6
D7
D8
GND
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
SEL0
PORT E0
PORT E1
PORT E2
PORT E3
PORT E4
PORT E5
PORT E6
PORT E7
C27
606
U18
MUXB_OUT
604b
P12
604a
C29
604

FIG. 6

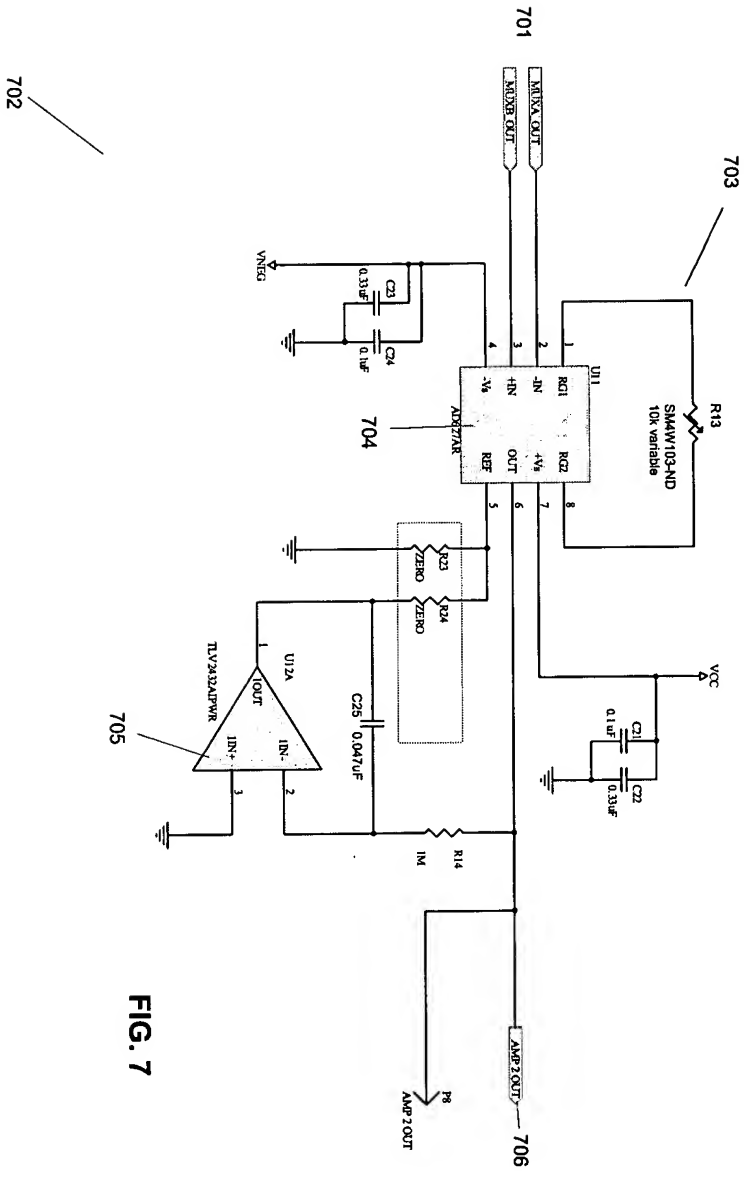

701
MUXB_OUT
MUXA_OUT
703
SM4W103-ND
10k variable
R13
U11
RG1
-IN
+IN
-Vs
REF
OUT
+Vs
RG2
AD8277AR
704
VNEG
C23
0.33uF
C24
0.1uF
VCC
C21
0.1uF
C22
0.33uF
R23
ZERO
R24
ZERO
U12A
TLV2432AIPWR
1OUT
1IN-
1IN+
C25
0.047uF
R14
IM
705
AMP2OUT
706
P8
AMP 2 OUT
702

FIG. 7

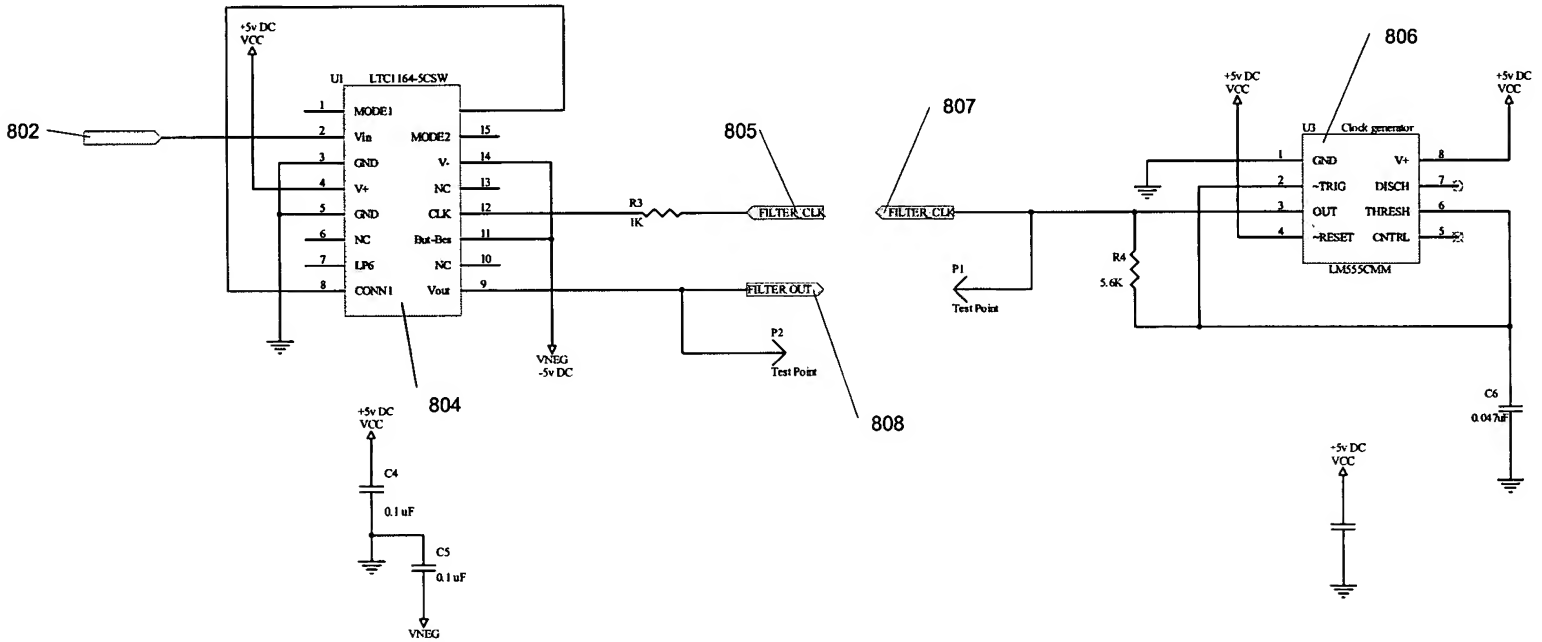

802
804
805
806
807
808
U1
LTC1164-5CSW
MODE1
Vin
GND
V+
GND
NC
NC
LP6
CONN1
MODE2
V-
NC
CLK
But-Res
NC
Vout
+5v DC
VCC
R3
1K
FILTER_CLK
FILTER_OUT
VNEG
-5v DC
P2
Test Point
C4
0.1 uF
C5
0.1 uF
VNEG
U3
Clock generator
GND
~TRIG
OUT
~RESET
V+
DISCH
THRESH
CNTRL
LM555CMM
R4
5.6K
P1
Test Point
C6
0.047uF

FIG. 8

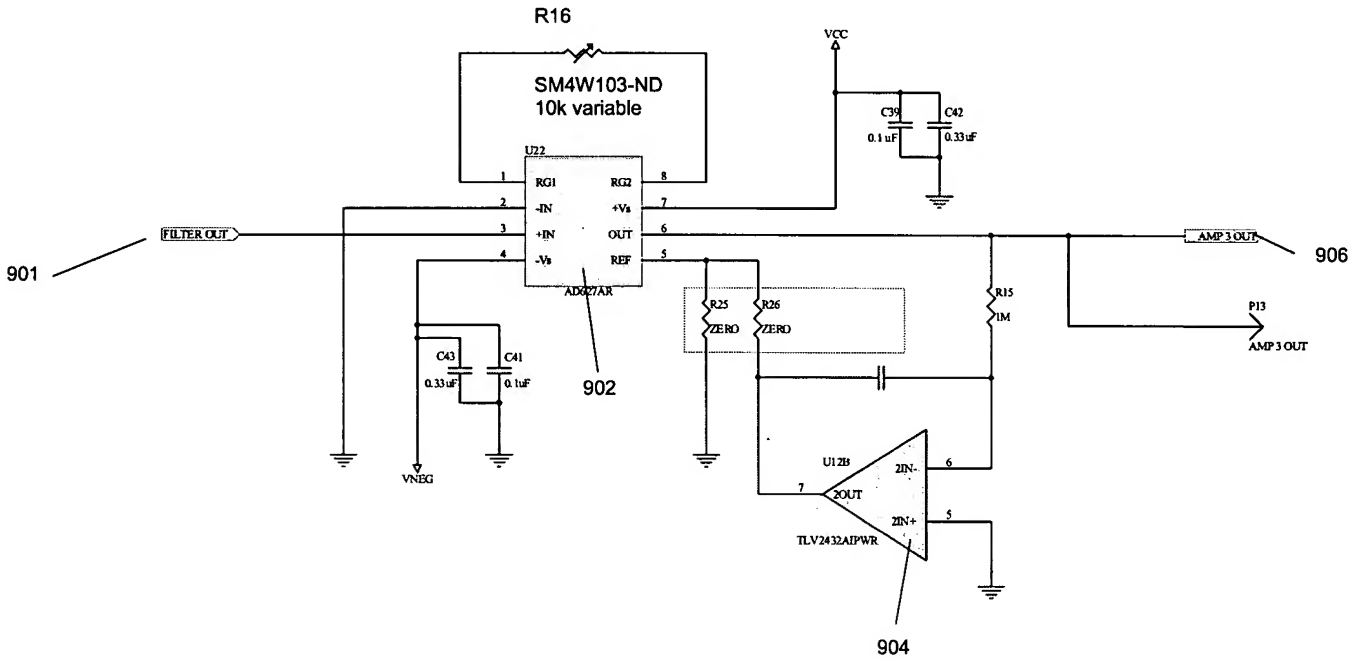

R16
SM4W103-ND
10k variable
VCC
C39
0.1 uF
C42
0.33 uF
U22
RG1
-IN
+IN
-Vs
RG2
+Vs
OUT
REF
AD627AR
FILTER OUT
AMP 3 OUT
901
906
902
R25
ZERO
R26
ZERO
R15
1M
P13
AMP 3 OUT
C43
0.33 uF
C41
0.1 uF
VNEG
U12B
2IN-
2OUT
2IN+
TLV2432AIPWR
904

FIG. 9

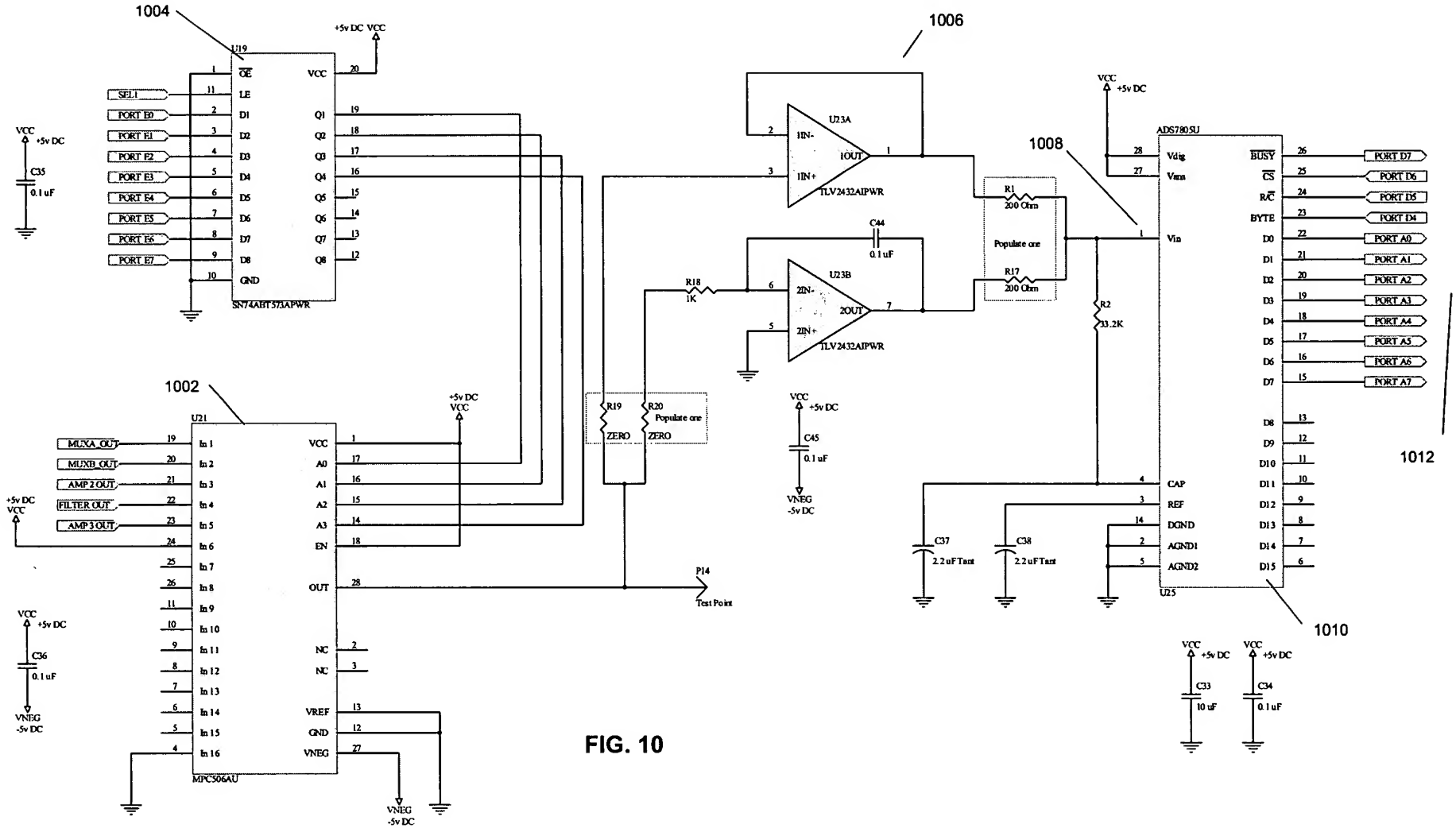
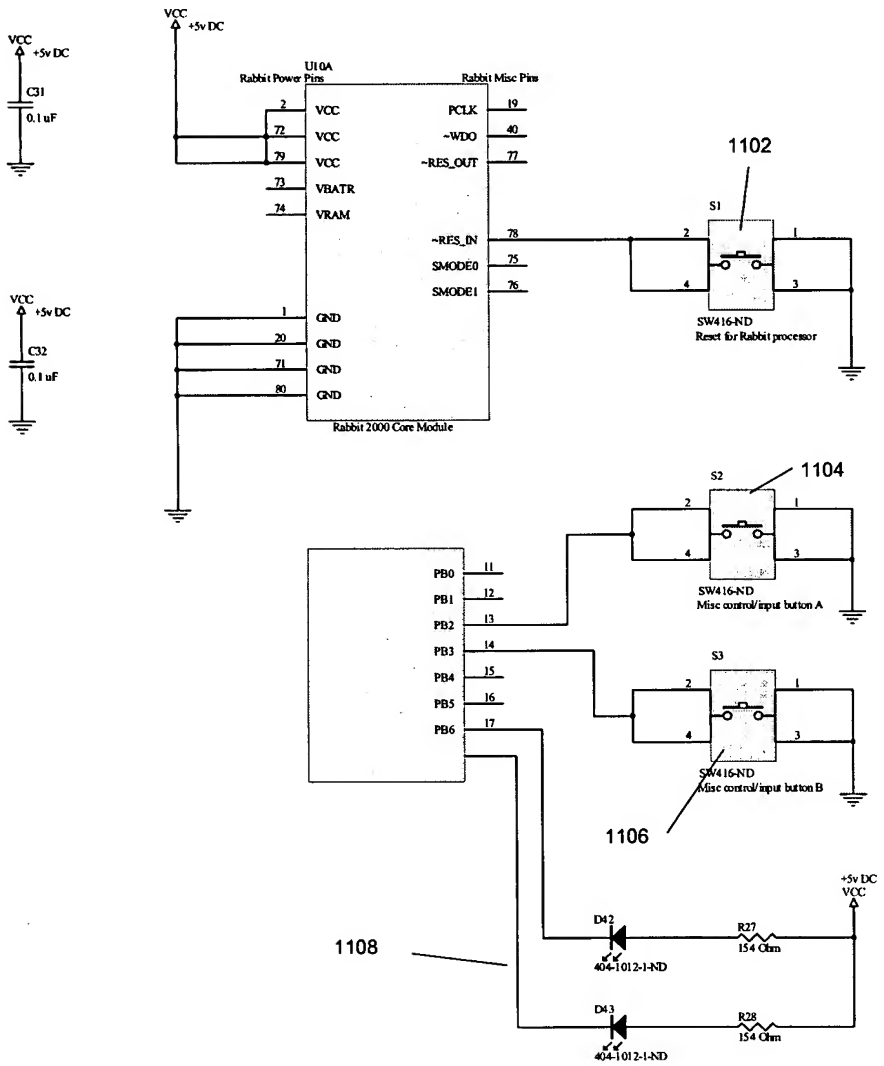

1004
1006
1008
1002
1012
1010
U19
SN74ABT573APWR
U23A
U23B
TLV2432AIPWR
ADS7805U
U21
MPC506AU
U25
SEL1
PORT E0
PORT E1
PORT E2
PORT E3
PORT E4
PORT E5
PORT E6
PORT E7
MUXA_OUT
MUXB_OUT
AMP 2 OUT
FILTER OUT
AMP 3 OUT
R1
200 Ohm
Populate one
R17
200 Ohm
R2
33.2K
R18
1K
R19
ZERO
R20
Populate one
ZERO
C44
0.1 uF
C45
0.1 uF
C35
0.1 uF
C36
0.1 uF
C37
2.2 uF Tant
C38
2.2 uF Tant
C33
10 uF
C34
0.1 uF
P14
Test Point
PORT D7
PORT D6
PORT D5
PORT D4
PORT A0
PORT A1
PORT A2
PORT A3
PORT A4
PORT A5
PORT A6
PORT A7
VCC
+5v DC
VNEG
-5v DC

FIG. 10


VCC
+5v DC
C31
0.1 uF
C32
0.1 uF
U10A
Rabbit Power Pins
Rabbit Misc Pins
VCC
VBATR
VRAM
PCLK
~WDO
~RES_OUT
~RES_IN
SMODE0
SMODE1
GND
Rabbit 2000 Core Module
1102
S1
SW416-ND
Reset for Rabbit processor
1104
S2
SW416-ND
Misc control/input button A
S3
SW416-ND
Misc control/input button B
1106
PB0
PB1
PB2
PB3
PB4
PB5
PB6
1108
D42
404-1012-1-ND
R27
154 Ohm
D43
404-1012-1-ND
R28
154 Ohm

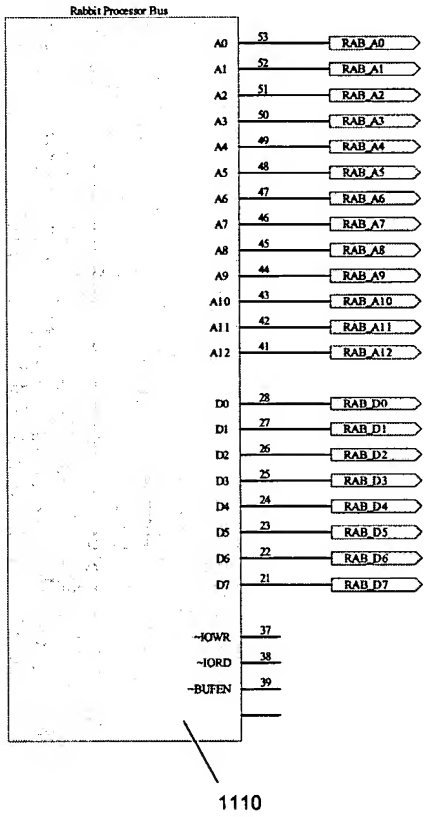

Rabbit Processor Bus
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
RAB_A0
RAB_A1
RAB_A2
RAB_A3
RAB_A4
RAB_A5
RAB_A6
RAB_A7
RAB_A8
RAB_A9
RAB_A10
RAB_A11
RAB_A12
D0
D1
D2
D3
D4
D5
D6
D7
RAB_D0
RAB_D1
RAB_D2
RAB_D3
RAB_D4
RAB_D5
RAB_D6
RAB_D7
~IOWR
~IORD
~BUFEN
1110

FIG. 11

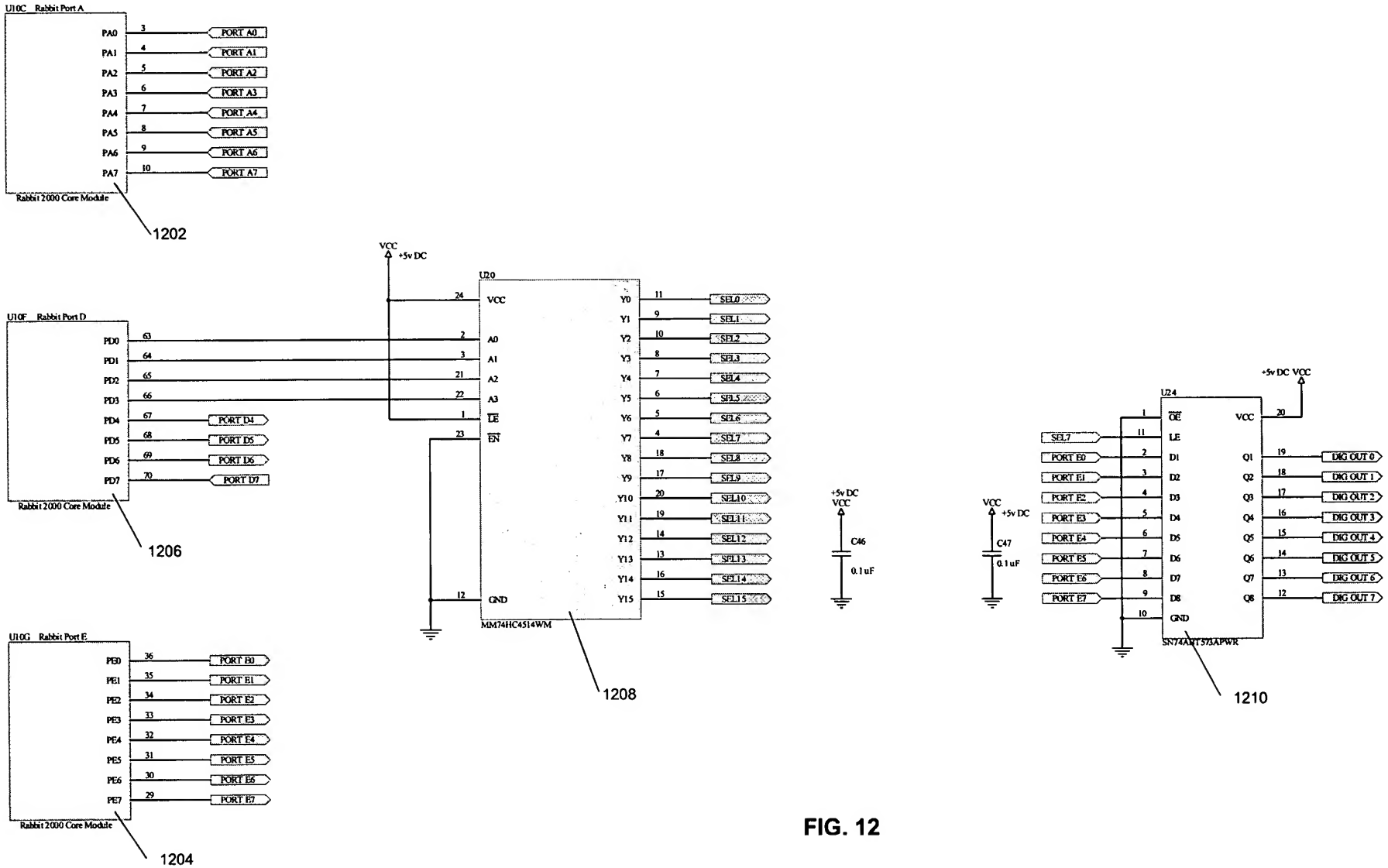

U10C Rabbit Port A
PA0
PA1
PA2
PA3
PA4
PA5
PA6
PA7
PORT A0
PORT A1
PORT A2
PORT A3
PORT A4
PORT A5
PORT A6
PORT A7
Rabbit 2000 Core Module
1202
U10F Rabbit Port D
PD0
PD1
PD2
PD3
PD4
PD5
PD6
PD7
PORT D4
PORT D5
PORT D6
PORT D7
Rabbit 2000 Core Module
1206
U10G Rabbit Port E
PE0
PE1
PE2
PE3
PE4
PE5
PE6
PE7
PORT E0
PORT E1
PORT E2
PORT E3
PORT E4
PORT E5
PORT E6
PORT E7
Rabbit 2000 Core Module
1204
VCC
+5v DC
U20
VCC
A0
A1
A2
A3
LE
EN
GND
Y0
Y1
Y2
Y3
Y4
Y5
Y6
Y7
Y8
Y9
Y10
Y11
Y12
Y13
Y14
Y15
SEL0
SEL1
SEL2
SEL3
SEL4
SEL5
SEL6
SEL7
SEL8
SEL9
SEL10
SEL11
SEL12
SEL13
SEL14
SEL15
MM74HC4514WM
1208
+5v DC
VCC
C46
0.1 uF
U24
OE
VCC
LE
D1
D2
D3
D4
D5
D6
D7
D8
GND
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
SEL7
PORT E0
PORT E1
PORT E2
PORT E3
PORT E4
PORT E5
PORT E6
PORT E7
DIG OUT 0
DIG OUT 1
DIG OUT 2
DIG OUT 3
DIG OUT 4
DIG OUT 5
DIG OUT 6
DIG OUT 7
+5v DC VCC
VCC
+5v DC
C47
0.1 uF
SN74ABT573APWR
1210

FIG. 12

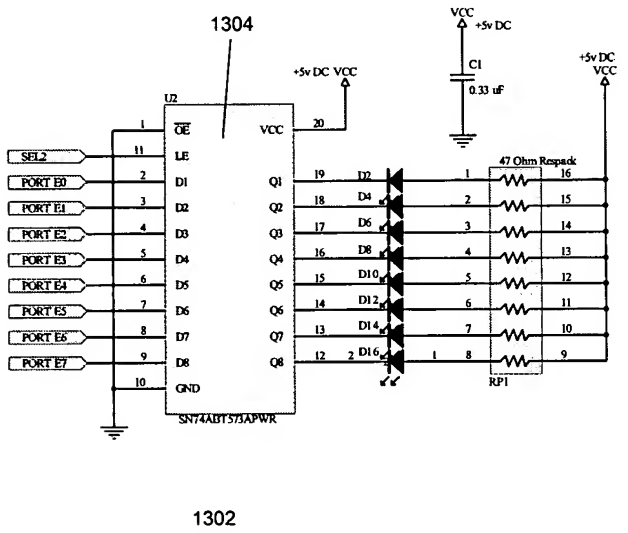

1304
U2
SEL2
PORT E0
PORT E1
PORT E2
PORT E3
PORT E4
PORT E5
PORT E6
PORT E7
OE
LE
D1
D2
D3
D4
D5
D6
D7
D8
GND
VCC
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
SN74ABT573APWR
+5v DC VCC
VCC
+5v DC
C1
0.33 uF
+5v DC
VCC
47 Ohm Respack
RP1
1302

FIG. 13

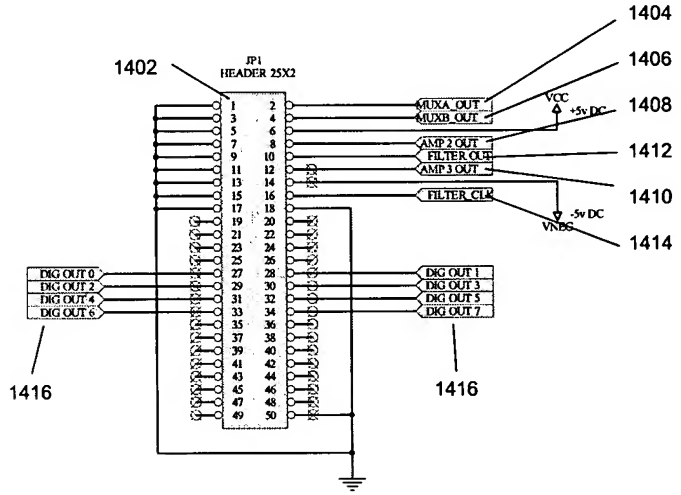

1404
1406
1408
1412
1410
1414
1402
JP1
HEADER 25X2
MUXA_OUT
MUXB_OUT
AMP 2 OUT
FILTER OUT
AMP 3 OUT
FILTER CLK
VCC
+5v DC
-5v DC
VNEG
DIG OUT 0
DIG OUT 2
DIG OUT 4
DIG OUT 6
DIG OUT 1
DIG OUT 3
DIG OUT 5
DIG OUT 7
1416
1416

FIG. 14

FIG. 15

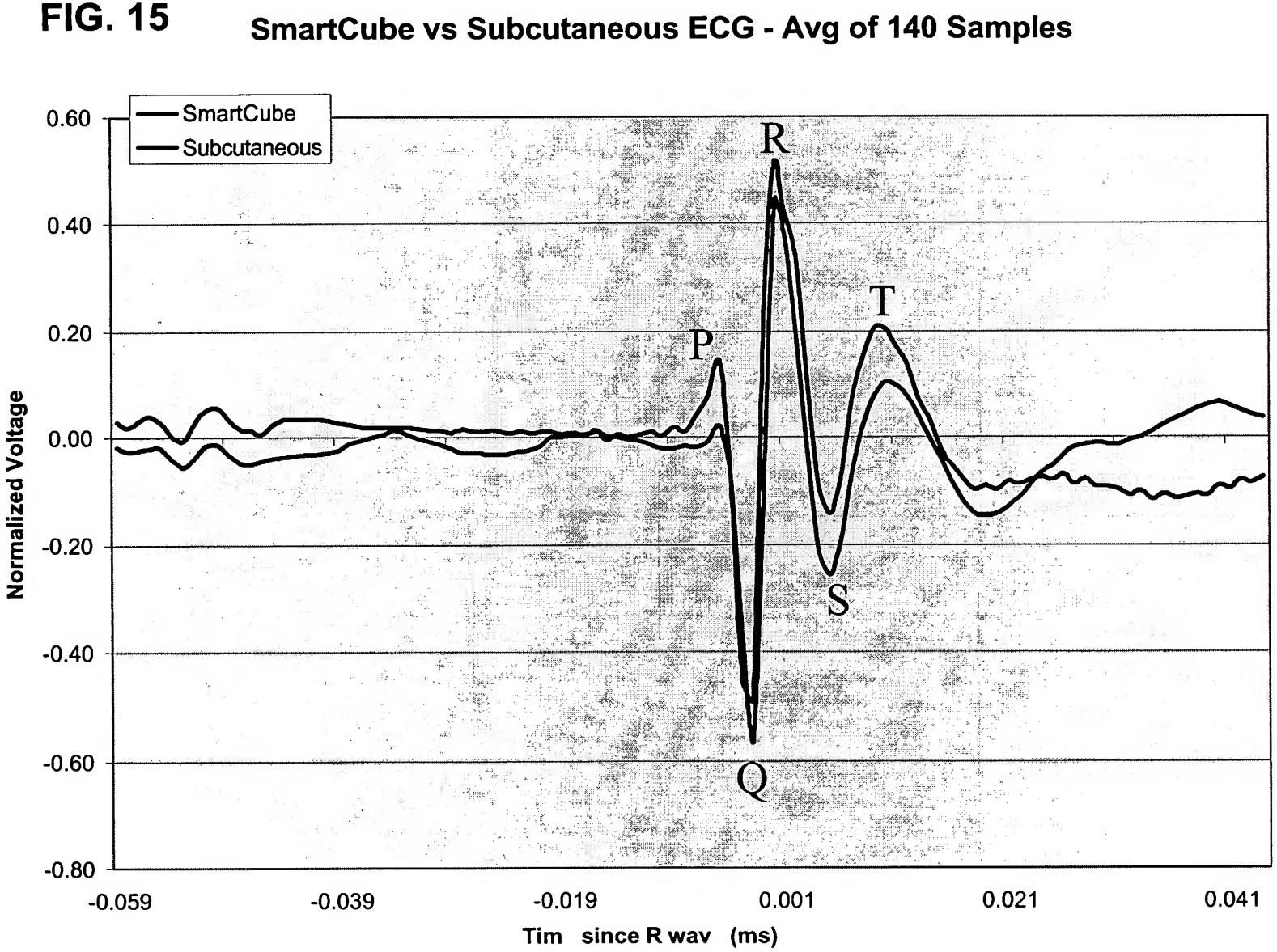
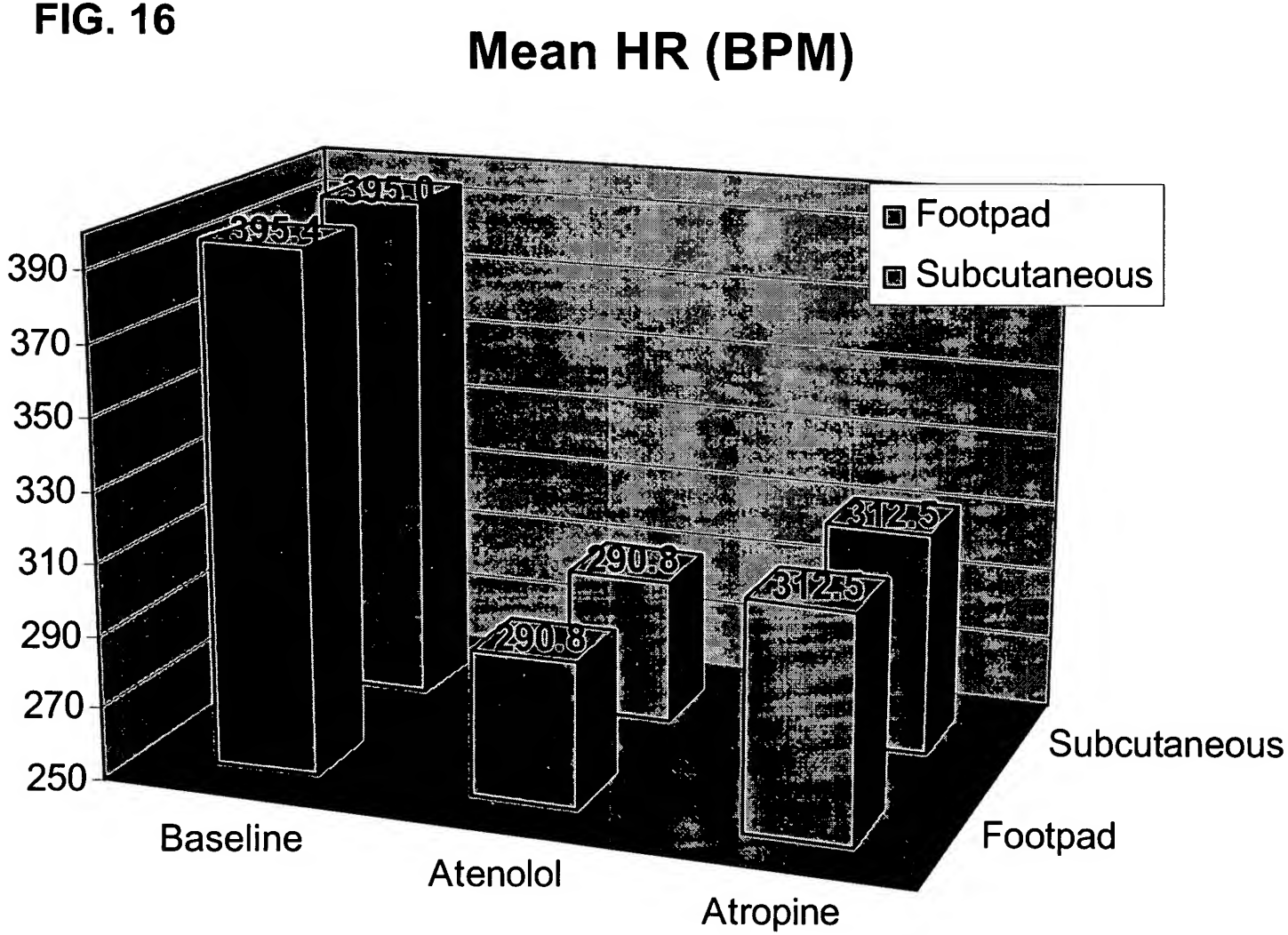

SmartCube vs Subcutaneous ECG - Avg of 140 Samples
SmartCube
Subcutaneous
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
Normalized Voltage
R
T
P
S
Q
-0.059
-0.039
-0.019
0.001
0.021
0.041
Tim since R wav (ms)

FIG. 16


Mean HR (BPM)
Footpad
Subcutaneous
390
370
350
330
310
290
270
250
395.1
395.1
290.8
290.8
312.5
312.5
Baseline
Atenolol
Atropine
Subcutaneous
Footpad